Space Weather Technical Forecast

Issued on Sunday 15 December 2024 at 01:09 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Isolated R1/R2 radio blackouts likely at first.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low activity with a peak C6.0 flare observed at 14/1729 UTC. There are four sunspot regions on the Earth-facing disc. The largest of these, AR3917, has seen some merging of its leading penumbral spots, but some decay of its intermediate and trailing spots, however any detail is becoming harder to see as it approaches the western limb. AR3924, in the south-centre disc, is the most developmental region at this time, with a mature leading region formed and numerous intermediate and trailing spots of smaller size that appear to be increasing in number. AR3920, in the northwest, has shown some decay in its leading portion, with spreading of its main, opposing polarity spots. The recently numbered AR3925 in the northeast remains a simple bipolar region.

No clear Earth-directed CMEs were observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE at L1, indicated an ongoing slow wind regime. Solar wind speeds were at background, typically varying between 300-350km/s. Density was below average initially, but increased to average levels from around 14/0800 UTC, becoming above average at times during the UTC evening. The Interplanetary Magnetic Field (IMF), Bt, was weak at first, but became moderate from 14/0900 UTC onwards. The north-south component, Bz, was mostly negative, initially weak but becoming moderate at times from 14/1330 UTC onwards. Over the whole period it varied between +6/-10nT. The phi angle was predominantly positive (away from the Sun). The net result of the above solar wind measures was for Quiet to Unsettled geomagnetic activity.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 showed a diurnal variation at moderate levels. The associated 24-hour fluence was below Active, and slowly declining. The 15/0000 UTC observation was 7.1e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is likely, with isolated M-class flares. There is a slight chance of isolated X-class flares.

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Solar Wind / Geomagnetic Activity: There are no clear Earth-directed CMEs as of the issue of this guidance.

A connection to a HSS from CH99/+ is expected through Day 1 (15 Dec). Geomagnetic activity is expected to start mostly Unsettled as a result, then rising to give spells of Active conditions, with a slight chance of G1 Minor Storm intervals. Activity and solar winds expected to ease into the new working week, returning conditions to mainly Quiet.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at Background, but with a daily slight chance of rising in response to any notable flares.

High energy electron flux is expected to be generally at background levels at first due to forecast faster solar winds from CH99. Moderate, perhaps high levels are likely by Days 3 and 4 (17-18 Dec) as solar winds from this feature eases. The 24-hour fluence is expected to remain below the Active threshold.

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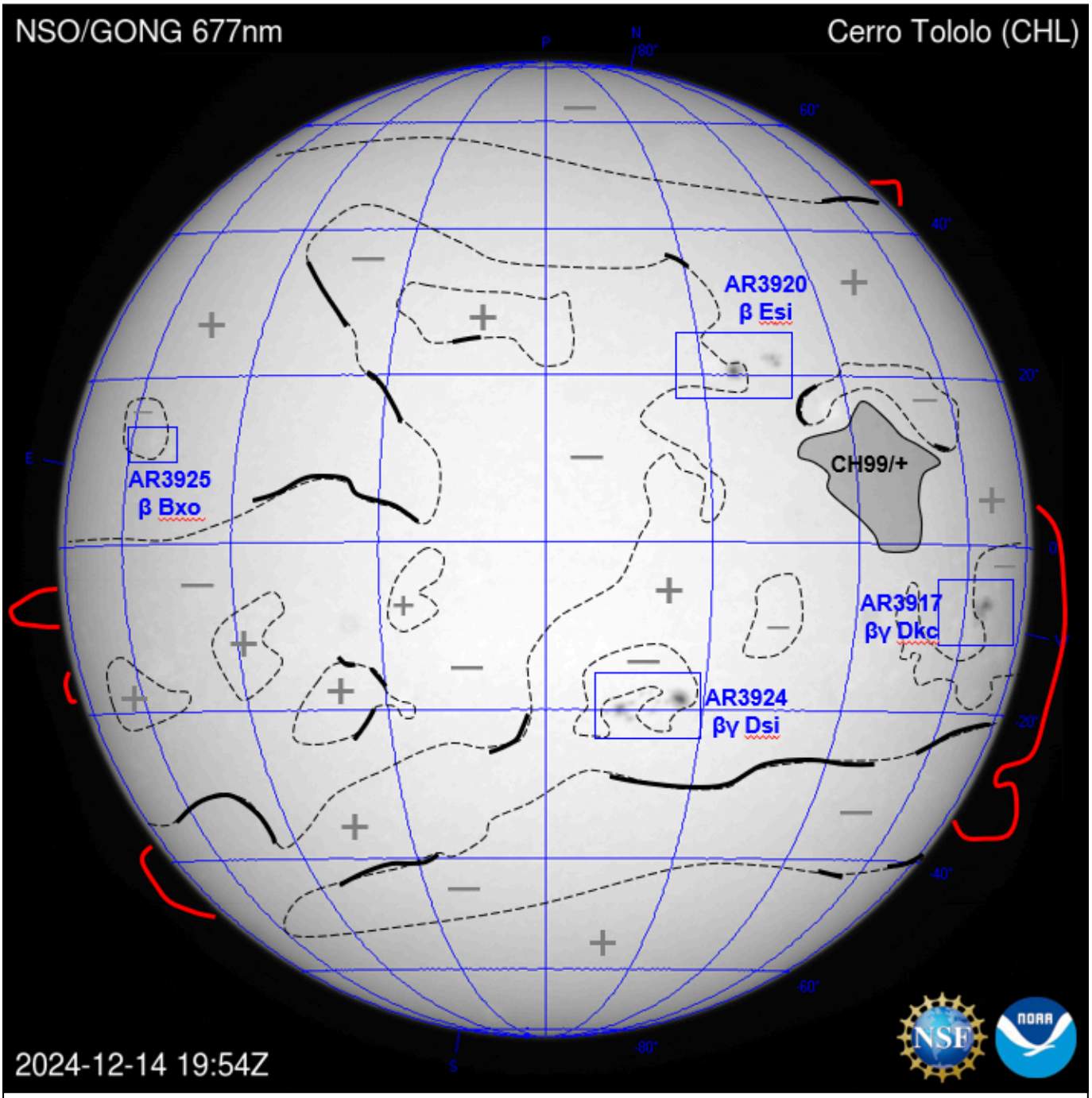
Figure 1: Solar Synoptic Map valid 14/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There are no Earth-directed CMEs in the forecast as of the time of issue, however this carries lower than average confidence due to ongoing imagery gaps and the large numbers of minor events on the disc. A dimming was observed in the south-centre disc around 14/1720 UTC, with imagery awaited as to whether any CME was given off. A number of significant filaments remain apparent on the visible disc, with one large filament in the southern hemisphere undergoing some disruption early on 14 Dec, and then appearing to erupt just before time of writing. Analysis will be done once available imagery comes in, but due to its location on the Sun, an Earth-directed CME is possible. A second filament eruption was observed in the northwest around 14/0800 UTC, but the resulting CME is not expected to be Earth-directed.

The coronal hole-based forecast is relatively higher confidence. Slightly enhanced geomagnetic activity has been observed, with an increase in density and magnetic field, most likely as a result of a connection to a HSS from coronal hole CH99/+, situated in the western hemisphere. This is a persistent feature, and was likely the cause of a weak enhancement that occurred on the previous rotation on 18 Nov with peak wind speeds of around 450km/s. This feature is expected through Day 1 (15 Dec), with current slow solar winds expected to increase as a result. Activity is most likely to be in the Unsettled to Active range through Day 1, with a slight chance of G1 Minor Storm intervals, before easing back into the new UTC working week, however the possibility of CME arrivals later in the period mean this is likely to change.

MOSWOC ENLIL output has the Earth already connected to the HSS from CH99 which is earlier than forecast, but does increase confidence for a connection to be observed. This is then followed by a more notable enhancement in the model occurring late on 16 Dec, which is too late to be from CH99 and has no observable source region currently on this disc. This is consequently considered anomalous and disregarded at this stage.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	20	5	1	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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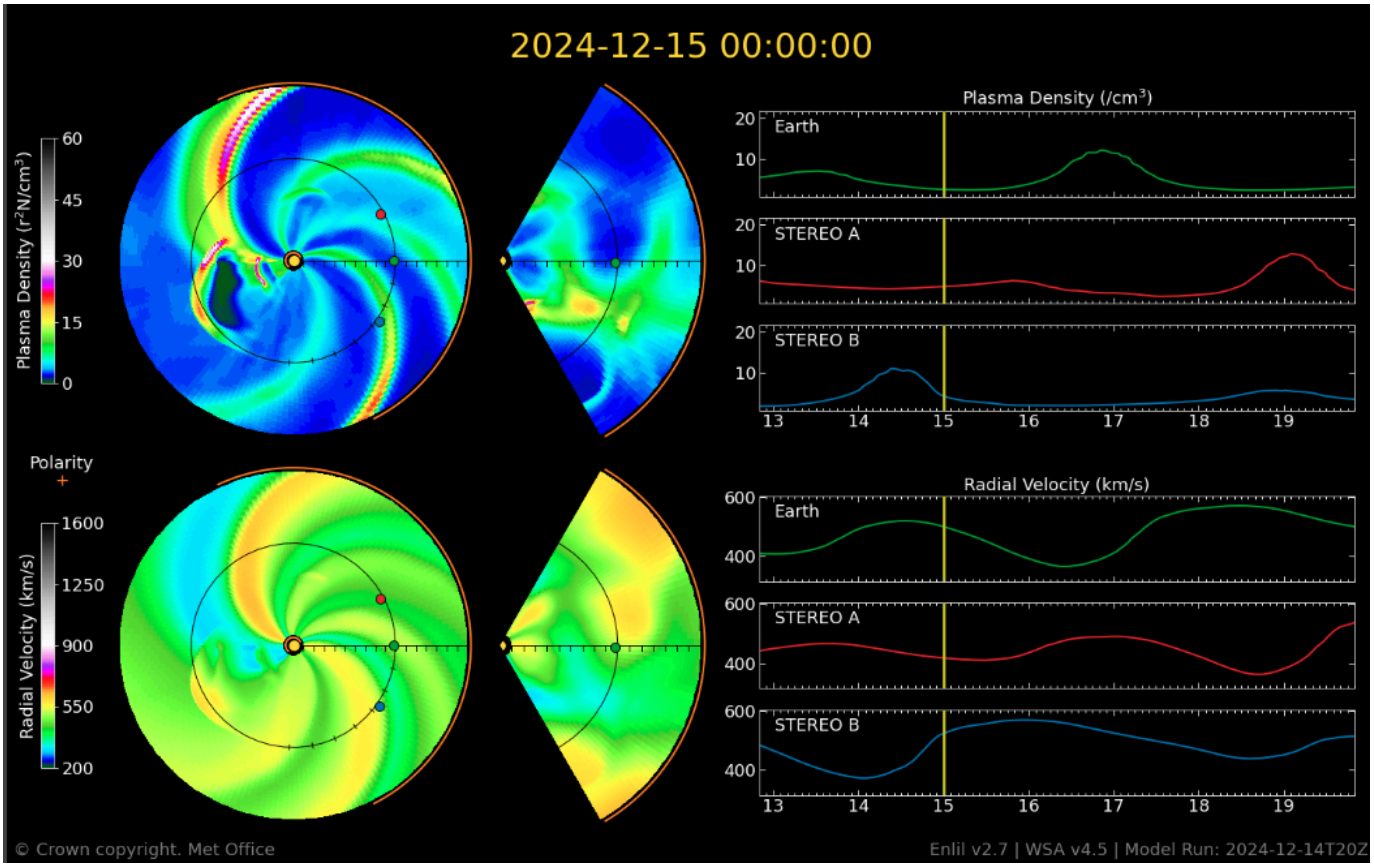
Figure 2: MOSWOC Enlil model.



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Radio Blackouts - X-Ray Flares

Solar Activity is currently Low with a peak C6.0 flare observed at 14/1729 UTC. There are currently four sunspot regions on the Earth-facing disc. The largest of these, AR3917, has seen some merging of its leading penumbral spots, but some decay of its intermediate and trailing spots, however any detail is becoming harder to see as it approaches the western limb. AR3924, in the south-centre disc, is the most developmental region at this time, with a mature leading region formed and numerous intermediate and trailing spots of smaller size that appear to be increasing in number. AR3920, in the northwest, has shown some decay in its leading portion, with spreading of its main, opposing polarity spots. The recently numbered AR3925 in the northeast remains a simple bipolar region.

Regarding the evolution of sunspot regions in the four days, AR3917 will begin to cross the western solar horizon from Day 2 (16 Dec) onwards. There also continues to be the potential for further regions to rotate onto the disc from over the east limb (perhaps corresponding to Ex-AR3911 and Ex-AR3901), with some clear magnetic structure evident on e.g. GOES SUVI 171. Overall we maintain a likelihood of isolated M-class flares with a persistent slight chance of isolated X-class flares, reducing slightly through the period as AR3917 rotates around the western limb.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	55	55	40	40
Very Active	R3-R5 (X Class)	No	10	10	5	5

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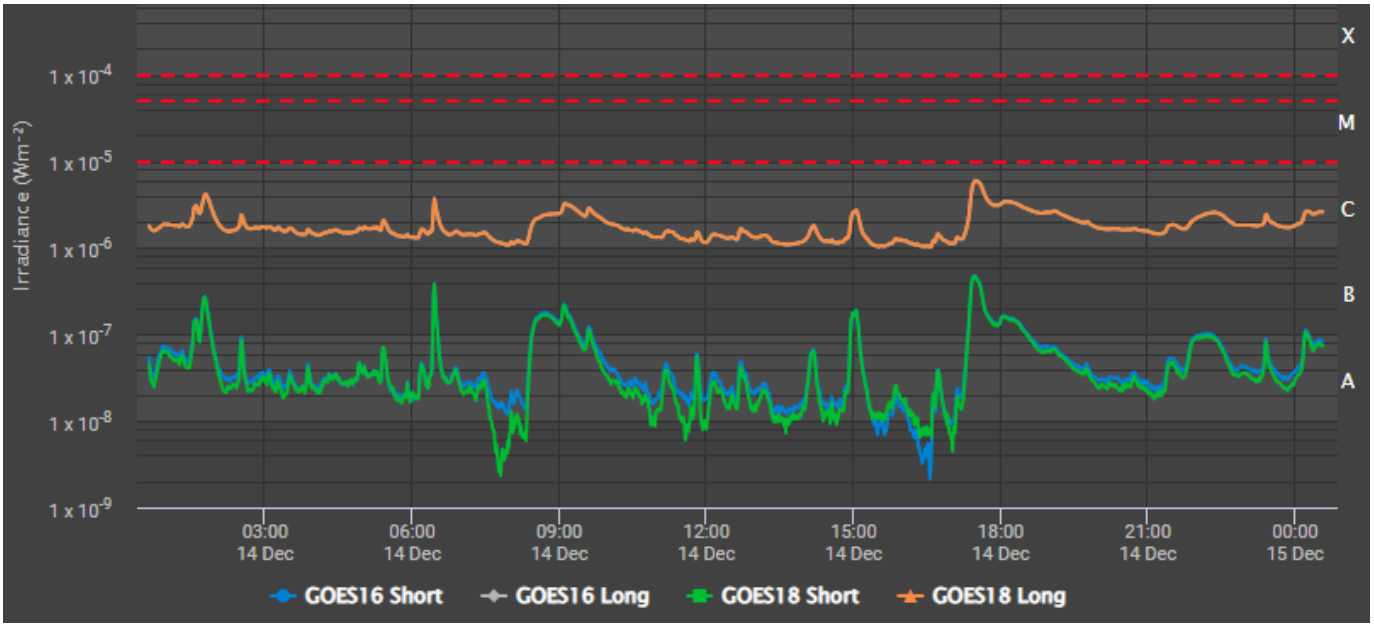
Figure 3: GOES-16 & -17 X-ray flux.



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Solar Radiation Storms (High Energy Protons)

GOES18 proton flux carries a daily slight chance of a response from any significant solar flares. Enhancement most likely from AR3917, which despite showing some signs of simplification and consolidation in extent maintains the risk of a significant flare. The risk is maintained throughout the forecast period, even as AR3917 rotates around the western limb.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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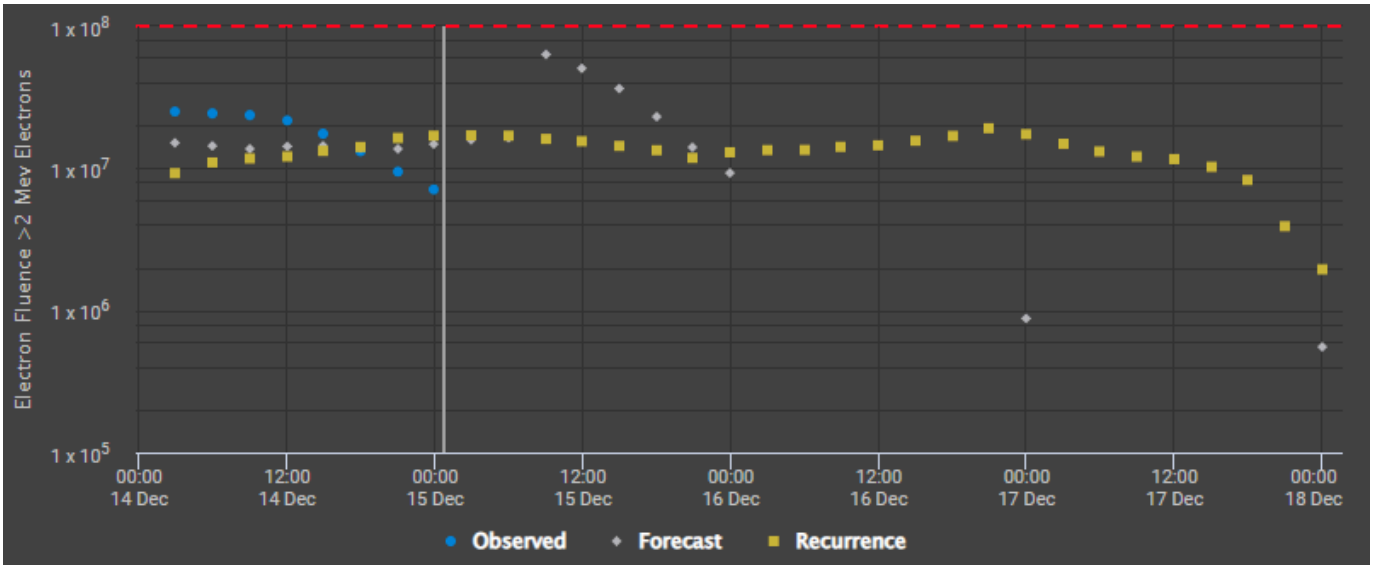
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has varied between background and diurnally moderate levels, following from the fast wind enhancement that occurred on 09-10 December. Observed flux is likely to drop out on Day 1 (15 Dec) as a consequence of the increased solar wind pressure from CH99/+. Electron flux is then expected to recover back to moderate, perhaps high values as the Van Allen belts ease back to encompass GEO into Days 3 and 4 (17-18 Dec).

The associated 24-hour fluence is well below the Active (1e8 integrated flux) threshold, on a declining trend. This is expected to continue through much of the period, before rising again through Days 3 and 4 (17-18 Dec), but expected to remain well below the Active threshold. This trend is generally supported by REFM, although the rising trend on Day 1 that REFM suggests appears unlikely.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	5	10
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 4: MOSWOC REFM.



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